

508.06. BASIS OF PAYMENT.

When shown on the Plan bid schedule, accepted quantities of "Removal of Culvert End" will be paid at the contract price per unit of measurement for the pay item listed below. Payment will be full compensation for the respective work prescribed in this section:

- (A) REMOVAL OF CULVERT END EACH

The quantities which constitute the completed and accepted structure will be measured for payment according to the contract documents for the several pay items as provided under Sections 501, 509, and 511 of these Specifications, which will be full compensation for all materials, falsework, labor, equipment, and incidentals necessary to complete the work as specified.

Payment for precast concrete box culverts will be made based on unit prices bid for the items and quantities of a cast-in-place box of the length required as determined by field measurements for the construction.

SECTION 509

STRUCTURAL CONCRETE

509.01. DESCRIPTION.

- (a) **General.** This work consists of furnishing, placing, finishing, and curing concrete in bridges, culverts, and miscellaneous structures in accordance with these specifications and in reasonably close conformity with the lines, grades, and dimensions specified in the contract documents. The work may include elements of structures constructed by cast-in-place and precast methods using either plain (unreinforced), reinforced, or prestressed concrete or any combination thereof.
- (b) **Related Work.** Other work involved in the construction of concrete structures shall be as specified in the applicable sections of this specification, especially Section 502, "Temporary Works," Section 503, "Prestressed Concrete Bridge Members," Section 504, "Concrete Bridge Decks," Section 511, "Reinforcing Steel for Structures," and Section 517, "Post-tensioning."

509.02. MATERIALS.

Conform to the requirements of following Sections and Subsections, except as otherwise specified:

Portland Cement Concrete	701
Fly Ash	702
Anchor Bolts for Bridge Structures	724.05
Elastomeric Bearing Pads	733.06
Waterstops	733.08
Concrete Surface Finish for Structures	737

509.04. CONSTRUCTION METHODS.

- (a) **General.** For handling and measuring materials, batching, and mixing, comply with the requirements of Subsections 414.04(c), (d), and (e) except as otherwise specified.

Whenever the contract documents the selection of the method or equipment to be used for any operation, employ methods and equipment which will produce satisfactory work under the conditions encountered and which will not damage any partially completed portions of the work.

Use falsework and forms conforming to Section 502, "Temporary Works." Fully support all concrete until the required strength and age has been reached.

(b) **Protection of Concrete from Environmental Conditions.**

1. *General.* Take precautions to protect concrete from damage due to weather or other environmental conditions during the placing and curing operations. Remove and replace, or repair to an acceptable condition, concrete that has been frozen or otherwise damaged by weather conditions.

Except as otherwise specified, place concrete only when the concrete temperature is between 50°F (10°C) and 90°F (32°C). Measure concrete temperature immediately before placement. Do not place concrete against any form (including the ground) or reinforcement colder than 35°F (2°C) or hotter than 100°F (38°C).

To determine ambient temperature, measure the temperature of the air in the shade 5 feet (1.5m) above the ground on the project.

Have available on the project site at least two maximum-minimum thermometers that are accurate within $\pm 5^\circ\text{F}$ (3°C). Maintain these devices in good working order. Install and provide temperature data from these devices as directed by the Engineer. Report readings and reset daily.

2. *Rain Protection.* Under conditions of rain, do not place concrete unless adequate protection is provided to prevent damage to the surface mortar or damaging flow or wash of the concrete surface.
3. *Hot Weather Protection.* Use a water spray or other approved methods to cool surfaces, hotter than 100°F (38°C), which will come in contact with the mix. Such surfaces include forms, reinforcing steel, steel beam flanges, etc.

Maintain the concrete temperature within the specified range by any combination of the following methods:

- Shade the materials storage areas and the production equipment.
- Cool the coarse aggregates by sprinkling with water conforming to the requirements of Subsection 701.04.
- Cool the aggregates or water by refrigeration or replace a portion or all of the mix water with flaked or crushed ice that will melt completely during mixing.
- Use liquid nitrogen injection.

4. *Cold Weather Protection.* Cold weather is defined as any time during the concrete placement or curing period the ambient temperature at the work site drops below 35°F (2°C). Before commencing cold weather concreting, have all material and equipment required for protection available at or near the project.

Remove all snow, ice, and frost from the surfaces, including reinforcement and subgrade, against which the concrete is to be placed. The temperature of any surface that will come

into contact with fresh concrete shall be at least 35°F (2°C) and shall be maintained at a temperature of 35°F (2°C) or above during the placement of the concrete.

If using heaters, place heaters and direct ducts so as not to cause concrete drying or fire hazards. Vent exhaust flue gases from combustion heating units to the outside of any enclosures. Heat the concrete components in a manner that is not detrimental to the concrete. Apply and withdraw the heat gradually and uniformly so that no part of the concrete surface is heated to more than 90°F (32°C) before set or caused to change temperature by more than 20°F (11°C) in 8 hours when removing protection.

Do not heat cement or permit the cement to come into contact with aggregates that are hotter than 100°F (38°C). Concrete at the time of placement shall be of uniform temperature and free of frost lumps. Do not heat aggregates with a direct flame or on sheet metal over fire. Do not heat fine aggregate by direct steam. The addition of salts to prevent freezing is not permitted.

During cold weather, protect the concrete for at least 7 calendar days so that the concrete surface temperature does not drop below 50°F (10°C). Extend the protection period to 10 days if fly ash, slag or silica fume is used in the concrete.

(c) **Handling and Placing Concrete.**

1. *General.* Handle, place, and consolidate concrete by methods that will not cause segregation of the mix and will result in a dense homogeneous concrete which is free of voids and rock pockets. Use methods that will not cause displacement of reinforcing steel or other materials to be embedded in the concrete.

Place and consolidate concrete before initial set and in no case before the time allowed under Table 509-1 has elapsed. Do not retemper concrete.

Table 509-1
Time Limits for Completion of Concrete Placement/Consolidation

Cement Type With and Without Admixtures	Time Limit ¹ (hour)
Type I or II	1.00
Type I or II with Retarding Admixture	1.50
Type III	0.75
Type III with Retarding Admixture	1.25

¹Begin time measurement when the cement is added to the mix.

Place concrete only after the Engineer has inspected and approved the forms, all materials to be embedded, and, for footings, the adequacy of the foundation material. Remove all mortar from previous placements, debris, and foreign material from the forms and steel before placement. Thoroughly moisten the forms and subgrade with water immediately before concrete is placed against them. Leave in place temporary form spreader devices until concrete placement precludes their need, then remove them.

Place concrete continuously without interruption between planned construction or expansion joints. The delivery rate, placing sequence and methods shall be such that fresh concrete is always placed and consolidated against previously placed concrete before initial

set has occurred in the previously placed concrete. Do not allow the time between the placement of successive batches to exceed 20 minutes. This period may be increased to 30 minutes when the ambient temperature during placement is less than 60°F (15°C). If a delay occurs causing the permissible time between successive batches to be exceeded and initial set has occurred before placement can be completed, make an emergency construction joint as specified in 509.04(d).

During and after placement of concrete, take care not to injure the concrete or break the bond with reinforcing steel. Keep workers off placed, fresh concrete. Do not support platforms for workers and equipment on any reinforcing steel. Once the concrete is set, do not apply forces to the forms or reinforcing steel which project from the concrete until the concrete is of sufficient strength to resist damage.

2. *Sequence of placement.* Comply with the form and falsework release requirements in Subsection 502.04(a)8.
 - 2.1 *Substructures.* Do not place loads on finished bents, piers, or abutments until concrete cylinder tests from the same concrete cured under the same conditions as the substructure element indicate that all concrete has at least 80% of its required 28-day compressive strength and has aged at least 7 days.
 - 2.2 *Vertical members.* For vertical members, such as columns, substructures, cast-in-place retaining walls, and culvert walls more than 16 feet (5m) in height, allow the concrete to set and settle (due to bleeding) for at least 12 hours before placing concrete for integral horizontal members, such as caps, slabs, or footings. For vertical members less than 16 feet (5m) in height, allow the concrete to settle for at least 30 minutes. When friction collars or falsework brackets are mounted on such vertical members, do not place concrete for horizontal members until the vertical member has been in place at least seven days or attained its required 28-day strength.
 - 2.3 *Superstructures.* Do not place concrete in the superstructure until substructure forms have been stripped sufficiently to determine the acceptability of the supporting substructure concrete. Do not place concrete in the superstructure until the substructure has attained the required strength.

Concrete for cast-in-place T-beams or pan girders may be placed in one continuous operation or two separate operations; first, to the top of the girder stems and second, to completion. If the section is more than 4 feet (1200mm) deep, place in two separate operations. Wait at least 5 calendar days after stem placement before placing the top deck slab concrete.

Concrete for box girders may be placed in two or three separate operations consisting of bottom slab, girder webs, and top slab or as shown on the plans. However, place the bottom slab first and do not place the top slab until the girder webs have been in place for at least 5 calendar days.

- 2.4 *Arches.* Place concrete in arch rings so that the centering is loaded uniformly and symmetrically.
- 2.5 *Box culverts.* Place the base slab of box culverts and allow to set 24 hours before placing the culvert wall concrete. For wall heights of 5 feet (1.5m) or less, the walls

and top slab may be placed in one continuous operation. For walls greater than 5 feet (1.5m) , the requirements for vertical members shall apply.

- 2.6 *Precast elements.* Place and consolidate concrete so that shrinkage cracks are not produced in the member.

3. *Placing methods.*

- 3.1 *General.* Place concrete as near as possible to its final position. Do not use vibrators for extensive shifting of the mass of fresh concrete.

Do not place concrete in horizontal layers greater than 18 inches (0.5m) thick. Do not exceed the vibrator capacity to consolidate and merge the new layer with the previous layer. Do not place concrete at a rate that, when corrected for temperature, exceeds the design loading of the forms.

Do not drop unconfined concrete more than 6 feet (2m) . Concrete may be confined by using a tube fitted with a hopper head or other approved device that prevents mix segregation and mortar spattering. This does not apply to cast-in-place piling or drilled shafts when concrete placement is completed before initial set occurs in the concrete placed first.

- 3.2 *Equipment.* Use equipment of sufficient capacity that is designed and operated to prevent mix segregation and mortar loss. Do not use equipment that causes vibrations that could damage the freshly placed concrete. Do not use equipment with aluminum parts that come in contact with the concrete. Remove set or dried mortar from inside surfaces of placing equipment.

Use chutes that are lined with smooth watertight material and, when steep slopes are involved, that are equipped with baffles or reverses.

Operate concrete pumps so that a continuous stream of concrete without air pockets is delivered at the tube discharge.

Do not use conveyor belt systems longer than 550 feet (170m) when measured from end to end of the total belt assembly. Arrange the belt assembly so that each section discharges into a vertical hopper to the next section without mortar adhering to the belt. Use a hopper, chute, and deflectors at the discharge end of the conveyor belt system to cause the concrete to drop vertically.

- 3.3 *Lighting.* If placing concrete during nighttime hours, provide sufficient lighting as necessary to make quality workmanship and adequate inspection possible. Exercise reasonable care to avoid interruptions during the hours of darkness, repair promptly any damage to the lighting system, and replace all burned out lamps as soon as possible.

4. *Consolidation.* Consolidate all concrete, except concrete placed underwater and as specified for drilled shafts, by mechanical vibration immediately after placement.

Except as noted herein, use internal vibration. External form vibrators may be used for thin sections when the forms have been designed for external vibration.

Vibrators shall be of approved type and design and of a size appropriate for the work. They shall be capable of transmitting vibration to the concrete at frequencies of not less than 75 hertz.

Provide a sufficient number of vibrators to properly compact each batch of concrete immediately after it is placed in the forms. Provide at least one spare vibrator immediately available in case of breakdown.

Manipulate vibrators to thoroughly work the concrete around reinforcement, embedded fixtures, corners, and angles in the forms. Vibrate the concrete at the point of deposit and at uniformly spaced points not farther apart than 1.5 times the radius over which the vibration is visibly effective. Insert vibrators so that the affected vibrated areas overlap. Do not use vibrators to move concrete. Insert vibrators vertically and slowly withdraw from the concrete. The vibration shall be of sufficient duration and intensity to thoroughly consolidate the concrete, but not to cause segregation. Do not vibrate at any point long enough to cause localized areas of grout to form. Do not vibrate reinforcement or through the reinforcement to sections or layers of concrete which have hardened to the degree that the concrete ceases to be plastic under vibration.

Supplement vibration with spading, as necessary, to ensure smooth surfaces and dense concrete along form surfaces, in corners, and at locations impossible to reach with the vibrators.

5. *Underwater placement.*

- 5.1 *General.* Underwater placement of concrete is permitted only for seal concrete and drilled shafts. Seal concrete is concrete used to seal out water in structures, such as cofferdams. For concrete placed underwater, increase the minimum cement content by 10% to compensate for loss due to wash. Refer to Section 516 for additional placement requirements for drilled shafts.

To prevent segregation of seal concrete, carefully place concrete under water in a compact mass, in its final position, using a tremie, concrete pump, or other approved method for placement. Maintain still water at the point of deposit. Forms under water shall be watertight. Vent cofferdams during placement and curing to equalize the hydrostatic pressure and thus prevent flow of water through the seal concrete.

Place seal concrete under water in a continuous manner from start to finish. Keep the concrete surface as level as practicable. To ensure thorough bonding, place each succeeding layer of seal concrete before the preceding layer has taken initial set. For large pours, use more than one tremie or pump to ensure compliance with this requirement.

5.2 *Equipment.*

- *Tremies.* Use watertight tremies, with a diameter of 10 inches (250mm) or more. Fit the top with a hopper. Use multiple tremies as required. Make tremies capable of being rapidly lowered to retard or stop the flow of concrete.

At the start of concrete placement, seal the discharge end and fill the tremie tube with concrete. Keep the tremie tube full of concrete to the bottom during placement. If water enters the tube, withdraw the tremie and reseal the discharge end. Maintain continuous concrete flow until the placement is completed.

- *Concrete pumps.* Use pumps with a device at the end of the discharge tube to seal out water while the tube is first being filled with concrete. When concrete

flow is started, keep the end of the discharge tube full of concrete and below the surface of the deposited concrete until placement has been completed.

- 5.3 *Cleanup.* Dewatering may proceed after test specimens cured under similar conditions indicate that the seal concrete has sufficient strength to resist the expected loads. Remove all laitance or other unsatisfactory materials from the exposed surface by scraping, chipping, or other means which will not injure the surface of the seal concrete before placing the foundation concrete.

(d) **Construction Joints.**

1. *General.* Make construction joints only where specified in the contract documents, unless otherwise approved. Extend all planned reinforced steel uninterrupted through joints. In the case of emergency, place construction joints as directed and, if directed, add steel dowels across the joint at no additional cost to the Department.
2. *Bonding.* Unless otherwise specified in the contract documents, horizontal joints may be made without shear keys and vertical joints shall be constructed with shear keys. Sufficiently rough float the surface of fresh concrete at a horizontal joint to thoroughly consolidate the surface. Leave the joint roughened. Shear keys shall consist of formed depressions in the surface of covering approximately one-third of the contact surface. Bevel the forms for keys so that removal will not damage the concrete.

Clean all construction joints of surface laitance, curing compound, and other foreign materials before fresh concrete is placed against the surface of the joint. Use abrasive blast or other approved methods to clean joints without shear keys to the extent that clean aggregate is exposed (full amplitude of approximately $\frac{1}{4}$ inch (6mm)). Use a stiff wire brush or other approved method for joints with shear keys. Flush all construction joints with water and allow to dry to a surface dry condition immediately before placing concrete.

3. *Doweling into Existing Concrete.* When the contract documents specify that new concrete be bonded to existing concrete structures, clean and flush the existing concrete as specified in Subsection 509.04(d)2. When the contract documents show reinforcing dowels grouted into holes drilled in the existing concrete at such construction joints, drill the holes by methods that will not shatter or damage the concrete adjacent to the holes. Drill holes to the depth specified in the contract documents or as approved. In no case shall the hole depth be less than either 15-bar diameters or the epoxy manufacturer's recommended depth for full development of the dowel, whichever is deepest. Make hole diameter just large enough to easily fit the dowel into the hole, but no larger than $\frac{1}{4}$ -inch (6mm) more than the dowel diameter.

Use Type IV epoxy meeting the requirements of Subsection 701.13. Before use, submit information on the proposed epoxy including its brand name, specification, type, class, and grade for approval. Use equipment and techniques that will ensure the epoxy components are properly proportioned, mixed, and placed.

Inject epoxy into the hole through a tube or hose of sufficient length to reach the closed end of the hole being filled. Fill the hole with epoxy starting from the closed end and fill to a depth such that when the dowel is inserted into the hole, excess epoxy runs out. Twist the dowel when inserting to insure a uniform coating of epoxy around the steel. In horizontal or

overhead applications, prevent the epoxy from running out of the hole after the dowel has been inserted. Wipe clean excess epoxy around the hole while the epoxy is still fluid.

If the approved epoxy product used is not consistent with this procedure, use the manufacturer's recommended procedure.

4. *Forms at Construction Joints.* When forms at construction joints overlap previously placed concrete, retighten the forms before depositing new concrete. Neatly form the face edges of all joints exposed to view with straight bulkheads or grade strips, or otherwise finish true to line and elevation.
- (e) **Installing Expansion and Contraction Joints.** Construct expansion and contraction joints at the locations, and in accordance with the details, specified in the contract documents. Such joints include open joints, filled joints, joints reinforced with steel armor, waterstops, compression seals, elastomeric expansion joint seals, and joints with combinations of these features.
1. *Open joints.* Form open joints with a wooden strip, metal plate, or other approved material. Remove the joint forming material without chipping or breaking the corners of the concrete. Do not extend reinforcement across an open joint. Finish the edge of non-armored joint using a $\frac{1}{2}$ inch (12mm) radius edging tool.
 2. *Filled joints.* Cut premolded expansion joint filler to the shape and size of the surface being jointed. Secure the joint filler on one surface of the joint using galvanized nails, waterproof adhesive, or other acceptable means. Make as few splices in the filler material as possible. Splice according to the manufacturer's recommendations. After form removal, remove and neatly cut all concrete or mortar that has sealed across the joint. Fill all joint gaps $\frac{1}{8}$ inch (3mm) or wider with hot asphalt or other approved filler. Place all necessary dowels, load transfer devices, and other devices as shown on the plans or as directed.
 3. *Steel Joints.* Refer to Section 504 for requirements for Metal Expansion Joints in bridge decks.
 4. *Water stops.* Place adequate waterstops of rubber or plastic as specified in the contract documents. Where movement of the joint is specified, use waterstops that permit such movement without injury.
- 4.1 *Rubber Waterstops.* Before installation, submit for approval the following.
- Performance test data.
 - One yard sample of each type of waterstop required.
 - If splices are used, at least one preliminary field splice.
- Form waterstops with a cross-section that is uniform in width and web thickness. Do not splice straight strips. Full-mold all junctions in the special connection pieces. Provide well cured, dense, homogeneous special connection pieces that are nonporous and are free from other defects.
- Fabricate splices that are dense and homogeneous throughout the cross-section. Fabricate splices watertight by vulcanizing or by mechanical means. Fabricate splices so they have a tensile strength of at least 50% of the reported tensile strength of the unspliced rubber waterstop.

- 4.2 *Plastic Waterstops.* Before installation, submit for approval at least one preliminary field splice sample.

Heat splices according to the manufacturer's instructions to make them watertight. Fabricate splices so they have a tensile strength of at least 80% of the reported tensile strength of the unspliced plastic waterstop.

- 4.3 *Placing Waterstops.* Carefully place and support waterstops. Prevent waterstops from being displaced or damaged by construction operations or other activities. Keep all surfaces of waterstops free from oil, grease, dried mortar, or any other deleterious material until embedded in concrete. Ensure that embedded portions of the waterstop are completely enclosed in dense concrete.

5. *Compression joint seals.* Use one piece compression joint seals for transverse joints and the longest practicable length for longitudinal joints. Clean and dry joints and remove spalls and irregularities. Apply a lubricant-adhesive as a covering film to both sides of the seal immediately before installation. Compress the seal and place it in the joint as recommended by the manufacturer. Make sure the seal is in full contact with the joint walls throughout its length.

Remove and discard all seals twisted, curled, nicked or improperly formed. Remove and reinstall joint seals that elongate more than 5% of their original length when compressed. Remove all excess lubricant-adhesive before it dries.

6. *Elastomeric expansion joint seal.* Install the joint according to the manufacturer's recommendations and in conformance with the contract documents.

(f) **Concrete Curing.**

1. *General.* Cure all newly placed concrete by use of one or more of the methods specified herein. Except as otherwise specified, begin curing immediately after the free surface water has evaporated and the finishing is complete. Do not damage the concrete surface with the application of the curing material. If the surface of the concrete begins to dry before the selected cure method can be started, keep concrete surface moist using a fog spray without damaging the surface.

Keep surfaces to be rubbed moist after forms are removed. Cure immediately following the first rub.

Unless using either the steam or radiant heat curing method, cure all concrete uninterrupted for at least 7 calendar days. If pozzolans, such as fly ash, in excess of 10 percent by weight of the Portland cement are used in the mix, cure uninterrupted for at least 10 calendar days. Except for concrete used in bridge floors and pavements, the above curing periods may be reduced and curing terminated if cylinders cured under the same conditions as the structure indicate that concrete strengths of at least 70% of that specified have been reached.

Refer to Subsection 701.07 for curing material requirements.

2. *Forms-in-place method.* For formed surfaces, leave the forms in place without loosening. If forms are removed during the curing period to facilitate rubbing, strip forms only from those areas able to be rubbed during the same shift. During rubbing, keep the surface of the exposed concrete moist. After the rubbing is complete, immediately continue curing process using

the water method or by applying a clear curing compound (Type 1-D) for the remainder of the curing period.

3. *Water method.* Keep the concrete surface continuously wet by ponding, spraying, or covering with material that is kept continuously and thoroughly wet. Covering material may consist of cotton mats, multiple layers of burlap, or other approved material that does not discolor or otherwise damage the concrete.
4. *Liquid membrane curing compound method.* Use Type 2, white pigmented, liquid membrane on the top surfaces of bridge decks and approach slabs or on surfaces not exposed to view in the completed work. Use Type 1-D clear curing compounds on other surfaces.

Mix membrane curing solutions containing pigments before use. Continue to agitate during application. Use equipment capable of producing a fine spray. Apply the curing compound at a minimum rate of 1 gallon per 160 square feet (1 liter per 4 square meters) in one or two uniform applications. If the solution is applied in 2 applications, follow the first application with the second application within 30 minutes and apply at right angles to the first application.

If the membrane is damaged by rain or other means during the curing period, immediately apply a new coat over the damaged areas.

Do not use the liquid membrane method on surfaces to receive a rubbed finish. Usage of curing compound on construction joint surfaces is permitted only if the compound is removed by sandblasting before placement of concrete against the joint.

5. *Waterproof cover method.* Cover the wet concrete surface with a waterproof sheet material that prevents moisture loss from the concrete.

Use widest sheets practical. Lap adjacent sheets at least 6 inches (150mm) and tightly seal all seams with pressure sensitive tape, mastic, glue, or other approved methods. Secure all material so that wind will not displace it. Immediately repair sheets that are broken or damaged.

6. *Steam or Radiant Heat Method.* Use this method only for precast concrete members manufactured in established plants.

Conduct steam curing or radiant heat curing under a suitable enclosure to contain the live steam or radiant heat and exclude outside air. Provide uniform temperature within the enclosure. Place the required temperature recorder inside the enclosure.

Apply steam or radiant heat after the initial set of all concrete in a line, or from 2 to 4 hours after final placement for normal set concrete and 4 to 6 hours after final placement for retarded set concrete. To measure time of initial set, use AASHTO T197 (ASTM C403), "Time of Setting of Concrete Mixtures by Penetration Resistance." After placement and before the application of steam or radiant heat, use steam or radiant heat as needed to maintain the temperature within the curing chamber between 50°F (10°C) and 90°F (32°C).

Prevent localized high temperatures on the members caused by live steam or radiant heat applied directly to the concrete, forms, or test cylinders. Limit the rate of ambient temperature change within the curing enclosure to 40°F (22°C) per hour. Do not exceed 160°F (70°C) within the enclosure. Hold the curing temperature near its peak until the required concrete detensioning strength has been reached. When discontinuing steam or

radiant heat, allow the ambient air temperature within the enclosure to cool to 20°F (10°C) above the temperature of the outside air. Do not reapply steam or radiant heat after cooling.

Use low pressure, saturated steam having 100 percent relative humidity for the steam method. Use pipes circulating steam, hot oil or hot water, or electric heating elements to apply radiant heat. When using the radiant heat method, also cover all exposed concrete surfaces with plastic sheeting or an approved liquid membrane curing compound. After the completion of curing, completely remove all residue of curing compound from surfaces to receive cast-in-place concrete or other materials requiring surface bonding.

Unless the ambient temperature is maintained above 60°F (16°C), transfer the stressing force for prestressed members immediately after discontinuing the steam or radiant heat curing.

- (g) **Finishing Formed Concrete Surfaces.** Remove and replace or repair, as approved, all rock pockets or honeycombed concrete. Provide a durable, tightly-bonded surface finish that is uniform in texture and color. Finish sound formed concrete surfaces as follows.

1. *Class 1 - Ordinary Surface Finish.* Finish all formed concrete surfaces with a Class 1, ordinary surface finish. If another class of surface finish is specified, apply the specified class of surface finish after the Class 1 finish is complete.

Begin finishing when the forms are removed. Remove fins and irregular projections from all surfaces that are exposed or will be waterproofed. Remove bulges and offsets with carborundum stones or discs. Remove localized poorly bonded rock pockets or honeycombed concrete and replace with sound concrete or packed mortar in an approved manner and as specified in Subsection 509.04(h). If, in the opinion of the Engineer, rock pockets or honeycombed concrete are of such an extent or character as to effect the strength of the structure materially or to endanger the life of the steel reinforcement, the Engineer may declare the concrete defective and require removal and replacement of the portions of the structure affected.

Clean and point all form tie cavities, holes, broken corners and edges, and other defects. Saturate the area with water. Finish the area with mortar that is less than 1 hour old. Use mortar complying with Subsection 509.04(h). After the mortar is set, rub it (if required) and continue curing. Match exposed surfaces to surrounding concrete.

Carefully tool and remove free mortar and concrete from construction and expansion joints. Leave joint filler exposed for its full length with clean, true edges.

Rub or grind bearing surfaces on piers and abutments to the specified elevation and slope.

If the final finished surface is not true and uniform, provide a Class 2, rubbed finish.

2. *Class 2 - Rubbed Finish.* If not otherwise specified in the contract documents, finish exposed concrete surfaces with a Class 2, rubbed finish, except the soffits of superstructures, the interior faces and bottoms of concrete girders, and the interior faces of reinforced concrete boxes.

Complete the Class 1 finish. Immediately before rubbing, saturate the concrete surface with water. Rub the surface with a medium coarse carborundum stone using a small amount of mortar on its face. Use mortar composed of cement and fine sand mixed in the same

proportions as the concrete being finished. Continue rubbing until form marks, projections, and irregularities are removed and a uniform surface is obtained. Leave the paste produced by this rubbing in place.

After other work that could affect the surface is complete, rub with a fine carborundum stone and water until the entire surface has a smooth texture and uniform color. After the surface has dried, rub it with burlap to remove loose powder. Leave it free from all unsound patches, paste, powder, and objectionable marks.

For slip formed surfaces, use appropriate tools and methods to achieve a rubbed finish appearance.

3. *Class 3 - Tooled Finish.* Provide a Class 3 surface finish only when specified. Let the concrete set for at least 14 calendar days or longer if necessary to prevent the aggregate particles from being “picked” out of the surface. Use air tools such as a bush hammer, pick, or crandall. Chip away the surface mortar and break the aggregate particles to expose a grouping of broken aggregate particles in a matrix of mortar.
4. *Class 4 - Sandblasted Finish.* Provide a Class 4 surface finish only when specified. Let the concrete set for at least 14 calendar days. Protect adjacent surfaces that are not to be sandblasted. Sandblast the surface with hard, sharp sand to produce an even fine-grained surface in which the mortar is cut away leaving the aggregate exposed.
5. *Class 5 - Wire Brushed or Scrubbed Finish.* Provide a Class 5 surface finish only when specified. Begin when the forms are removed. Scrub the surface with stiff wire or fiber brushes using a solution of muriatic acid. Mix the solution in the proportion of 1 part acid to 4 parts water by volume. Scrub until the cement film or surface is completely removed and the aggregate particles are exposed. Leave an even pebbled texture having the appearance of fine granite to coarse conglomerate depending upon the size and grading of aggregate. Wash the entire surface with water containing a small amount of ammonia.
6. *Class 6 - Mortar Finish.* Unless otherwise specified in the contract documents, a Class 6 surface finish may be provided instead of Class 2 surface finish except for bearing surfaces. Use cement mortar complying with Section 737 as a surface finish coating. Provide a color slightly lighter than the natural color of concrete, unless otherwise specified.

Build a sufficient number of 18 inch (0.5m) by 36 inch (1m) concrete finish sample panels to obtain a color acceptable to the Engineer. Protect the approved sample panel at all times during the work. Finish all designated surfaces to match the color of the approved sample.

Do not apply the mortar finish until all other work that might mar or deface the surface finish is complete. After completing the Class 1 surface finish, remove all dust, foreign matter, form oil, grease, curing compound, or other deleterious material by lightly abrasive cleaning the surface. Wash the surface with a jet spray of clean water.

Use paper, cloth, or other means to protect surfaces not to be color finished. Apply the finish to a dry concrete surface when the surface temperature is 50°F (10°C) or higher and the air temperature in the shade is anticipated to be 50°F (10°C) or higher during the 24 hours following application.

Apply the finish according to the manufacturer's recommendations. Apply the coating with an approved plaster type spray gun or by the brush and float method. Cure cement-based mortar coatings in the same manner as required for curing concrete.

Clean concrete areas not intended to be covered by the finish using an approved method. Clean and recoat defective areas at no additional cost.

7. *Class 7 - Paint Finish.* Paint concrete only when specified in the contract documents. When painting concrete, comply with Sections 512 and 737.

For all classes of surface finishes except Class 7 - Paint Finish, apply penetrating water repellent treatment after completion of the surface finish. Apply water repellent before painting. Refer to Section 515 for water repellent requirements.

(h) **Mortar and Grout.**

1. *General.* This work consists of making and placing of mortar and grout for use in concrete structures other than in prestressed ducts. Such uses include mortar to fill voids and repair surface defects and grout used to fill sleeves for anchor bolts.
2. *Materials and Mixing.* Use materials for mortar and grout conforming to the requirements of Section 701. Modify the grading of sand for use in grout or for use in mortar when the width or depth of the void to be filled is less than $\frac{3}{4}$ inch (20mm), so that all material passes the No. 8 (2.36mm) sieve. Use Type I Portland Cement and air entraining admixture. Unless otherwise specified or directed, use one part cement to two parts sand for mortar and one part cement to one part sand for grout. Proportion by loose volume.

When non-shrink mortar or grout is specified, use either a non-shrink admixture or an expansive hydraulic cement conforming to ASTM C 845 of an approved type.

Use only sufficient water to permit placing and packing. For mortar, use only enough water so that the mortar will form a ball when squeezed gently in the hand.

Do mixing by either by hand methods or with rotating paddle-type mixing machines. Continue mixing until all ingredients are thoroughly mixed. Do not retemper mortar or grout. Place within one hour.

3. *Placing and Curing.* Clean all loose and foreign material that would in any way prevent bond, from areas to be in contact with mortar or grout. Flush with water and allow to dry to a surface dry condition immediately before placement.

Completely fill and tightly pack with mortar or grout recesses and holes and other locations specified. Cure all surfaces of mortar and grout using the water method for at least three days. Do not load mortar or grout before the end of curing.

Remove and replace defective mortar and grout.

(i) **Application of Loads.**

1. *General.* Do not apply load to concrete structures until the concrete has attained sufficient strength and, when applicable, sufficient prestressing has been completed, so that damage will not occur. Determine strengths from test cylinders cured at the work site under similar conditions as the structure as specified in Section 701.
2. *Earth Loads.* Whenever possible, use a sequence of placing backfill around structures such that overturning or sliding forces are minimized. When the placement of backfill will cause

flexural stresses in the concrete, and unless otherwise permitted by the Engineer, allow concrete to reach at least 80 percent of its specified strength and age at least 7 days before placing backfill.

For a rigid frame bridge or a bridge where the abutments are designed to be integral with the superstructure, do not backfill the abutments until the superstructure is in place and forms supporting girders and deck are removed. Do not place embankment around any supporting form.

3. **Construction Loads.** Allow the concrete in substructure elements, such as drilled shafts, piers, pier caps, and abutments, to reach at least 80 percent of its specified strength and age at least 7 days before loading these elements with girders, precast concrete or steel.

Refer to Section 504 for requirements regarding construction loads on bridge decks.

In general, limit construction loads on existing, new, or partially completed portions of structures to the load carrying capacity of the structure as determined by the current AASHTO *Standard Specifications for Highway Bridges*. Use the lowest measured, actual strength of the structure in computing capacities.

- (j) **Concrete Anchorage Devices.** Use chemical, grouted, or cast-in-place concrete anchorage devices for attaching equipment or fixtures to concrete. Furnish the following:

- Concrete anchorage device sample.
- Manufacturer's installation instructions.
- Material data and certifications.

Fabricate all metal parts of the anchorage devices from stainless steel or from steel protected with a corrosion resistant metallic coating that does not react chemically with concrete. Supply anchorage devices complete with all hardware.

For chemical or grouted anchors, conduct a system approval test on one anchor at the job site, not to be incorporated in the work. Conduct a static load test according to ASTM E 488. Demonstrate that the anchorage device will withstand a sustained direct tension test load not less than the values shown in Table 509-2 for at least 48 hours with movement not to exceed 0.035 inch. Also demonstrate that when loaded to failure, the anchor device displays a ductile failure of the anchor steel, not a failure of the chemical, grout, or concrete.

Table 509-2
Sustained Load Test Values

<u>Anchorage Device Stud Size (inches)</u>	<u>Tension Test Load (lb)</u>
$\frac{1}{4}$	1000
$\frac{3}{8}$	2100
$\frac{1}{2}$	3200
$\frac{5}{8}$	4100
$\frac{3}{4}$	5100

Table 509-2 (Metric)
Sustained Load Test Values

<u>Anchorage Device Stud Size</u>	<u>Tension Test Load (kN)</u>
M20	24.0
M16	18.3
M12	12.7
M8	7.1

Install concrete anchorage devices as recommended by the device manufacturer and so that the attached equipment or fixtures will bear firmly against the concrete. Torque installed nuts to the values specified in Table 509-3 unless otherwise specified in the manufacturer's instructions.

Table 509-3
Torque for Anchorage Devices

<u>Anchorage Device Stud Size (inches)</u>	<u>Torque (ft-lbs)</u>
$\frac{1}{4}$	10
$\frac{3}{8}$	35
$\frac{1}{2}$	60
$\frac{5}{8}$	90
$\frac{3}{4}$	125

Table 509-3 (Metric)
Torque for Anchorage Devices

<u>Anchorage Device Stud Size</u>	<u>Torque (N-m)</u>
M20	180
M16	130
M12	80
M8	30

In the presence of the Engineer, proof load a random sample of at least 10 percent of the anchors to 90 percent of the yield stress of the steel. If any anchor fails, reset the failed anchor and proof torque the reset anchor and 100 percent of all remaining anchors. The proof load may be applied by torquing against load indicator washers, applying direct tension load to the anchor, or another method approved by the Engineer. After proof loading, release the load on the anchor and retighten to the load specified in Table 509-3 or according to the manufacture's instructions.

(k) Girder Bearings.

1. *Concrete Bearing Surfaces.* Finish concrete bearing surfaces to meet the requirements for Class 2, rubbed surface finish, and to provide full and even bearing.

Check concrete bearing surfaces, in the presence of the Engineer, for smoothness, levelness, and elevation before erecting girders. Build the concrete bearing surface to be within $\frac{1}{4}$ inch (6mm) of the specified elevation and sloping no more than 0.5 percent from horizontal, measured at all locations and directions on the bearing surface. If bearing surfaces are at improper elevations, not level, or if bearings cannot otherwise be set properly, notify the Engineer and submit a written proposal to modify the installation for approval.

2. *Anchor Bolts.* Furnish threaded, galvanized anchor bolts conforming to Subsection 724.05 or as specified in the contract documents.

Install anchor bolts in the same manner as specified in Subsection 509.04(d)3 for construction joint dowels or preset them before placing the concrete. Do not restrict free movement of the superstructure at movable bearings by anchor bolts or nuts.

3. *Bearing Assemblies.*

- 3.1 *Drawings.* Prepare and submit drawings for the bearings according to Subsections 105.02 and 733.06, and Section 506 as applicable. Show all details of the bearings including the material proposed for use. Obtain approval before beginning fabrication.
- 3.2 *Fabrication.* Preassemble bearing assemblies in the shop and check for proper completeness and geometry.

- 3.3 *Packaging, handling, and storage.* Before shipping from the manufacturer, clearly identify each bearing component and mark on its top the location and orientation in the structure. Securely bolt, strap, or otherwise fasten the bearings to prevent any relative movement.

Package bearings so they are protected from damage due to shipping, handling, weather, or other hazards. Do not dismantle bearing assemblies at the site except for inspection or installation. Store all bearing devices and components at the work site in a location that provides protection from environmental and physical damage.

- 3.4 *Construction and Installation.* Clean the bearings of all deleterious substances. Install the bearings to the positions shown on the drawings. Set bearings and bearing components to the dimensions shown on the drawings or as prescribed by the manufacturer. Adjust according to the manufacturer's instructions to compensate for installation temperature and future movements of the bridge.

Bed metallic bearing assemblies, not embedded in concrete, on concrete with an approved filler or fabric material. Set elastomeric bearing pads directly on properly prepared concrete surfaces without bedding material. Machine bearing surfaces seated directly on steel to provide a level and planar surface upon which to place the bearing.

- 3.5 *Elastomeric Bearing Pads.* Provide elastomeric bearing pads conforming to Subsection 733.06 unless otherwise specified.

Place bearings on a level surface. Correct any misalignment in the support to form a level surface. Do not weld steel girders or base plates to the exterior plates of the bearing unless there is more than $1\frac{1}{2}$ inch (38mm) of steel between the weld and elastomer. Do not expose the elastomer or elastomer bond to instantaneous temperatures greater than 400°F (200°C) .

- 3.6 *Other Bearing Types.* Provide and install other types of bearing devices conforming to the requirements of the AASHTO Standard Specification for Highway Bridges.

(l) **Miscellaneous Construction.**

1. *Waterproofing.* Waterproof reinforced concrete retaining walls, abutments, earthfilled arches, etc., when specified in the contract documents. Conform to the requirements of Sections 606 or 607, depending upon the type specified.
2. *Drainage and Weep Holes.* Construct drainage and weep holes in the location and manner specified in the contract documents or as directed.
3. *Pipes and Conduits.* Install pipes and conduits for utility service lines to be embedded in concrete or attached to the concrete surface. Provide the pipes, conduits, and support hardware if so specified in the contract documents.

- (m) **Testing.** Randomly selected batches of fresh structural concrete will be tested for slump, air content, and temperature, and cylinders for compressive strength tests will be made from these batches. Compressive strength will be evaluated under Subsection 701.01.

Make compressive strength cylinders for controlling construction operations as required and needed. Perform other testing as required and needed to assure compliance with these specifications.

509.05. METHOD OF MEASUREMENT.

Structural concrete will be measured by the cubic yard (cubic meter) . Measurement will be according to the neat lines of the structure as shown on the plans except as altered by the Engineer to fit field conditions. No deduction will be made for the volume occupied by reinforcing steel, anchors, weep holes, piling, or pipes/ducts less than 8 inches (200 mm) in diameter.

For volumes of concrete having strengths less than the specified requirements but accepted under Subsection 105.03, the pay reduction factor for the represented volume of concrete will be computed by the following equation:

$$\text{Pay Reduction Factor} = (\text{Actual Strength/Specified Strength})^2$$

The contract price will be multiplied by pay reduction factor for the represented volume of concrete.

When *Class A concrete, small structures* is shown as a bid item in the contract documents, Class A concrete used in structures having less than 20 cubic yards (15 cubic meters) of total concrete volume per structure will be measured by the cubic yard under this item.

Anchor bolt assemblies (threaded bars, nuts, and washers), anchor plates not embedded in concrete, and diaphragm bolt assemblies (threaded-end bars, couplers, nuts, plates, and washers) will be measured as structural steel under Section 506.

Bearing assemblies and components, such as, elastomeric bearing pads, pot bearings, TFE bearings, fillers, etc., will not be measured for payment. Include the cost of these items in the price bid for related superstructure items of work.

509.06. BASIS OF PAYMENT.

The accepted quantities, measured as specified in this Section, will be paid at the contract price per unit of measurement for the pay items listed below that are shown in the Plan bid schedule. Payment will be full compensation for the respective work prescribed in this Section.

- (A) CLASS AA CONCRETE CUBIC YARD (CUBIC METER)
- (B) CLASS A CONCRETE CUBIC YARD (CUBIC METER)
- (C) CLASS A CONCRETE, SMALL STRUCTURES .. CUBIC YARD (CUBIC METER)
- (D) CLASS C CONCRETE CUBIC YARD (CUBIC METER)
- (E) CLASS P CONCRETE CUBIC YARD (CUBIC METER)